

INFS3101 / 7100 Ontology and the Semantic Web

Module 7 Formal Upper Ontologies

INFS3101/INFS7100 week 6, 22 November,
2005

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Last lecture: Key Terms



- ❖ Common to represent things as **objects** in **classes**. Objects have **properties**. Superclass **subsumes** subclass, superproperty **subsumes** subproperty. Properties have **metaproperties** **rigid**, **essential**, **identity**, **unity** which govern subsumption. Subclasses can be **defined** or **declared**.

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Universal ontologies

- ❖ Some people try to build ontologies which hold for all applications
 - Cyc, Sumo, Wordnet
- ❖ But social reality is extremely varied and complex
- ❖ Week 2 on semantic heterogeneity
- ❖ Many large failures of attempts to build common data models within a single large organization
- ❖ Universal content ontologies unlikely to succeed

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Formal upper ontologies

- ❖ Want to be able to re-use aspects of ontologies
- ❖ Content very difficult due to semantic heterogeneity
- ❖ But structure can be extracted
- ❖ Since content-free, can be universal
- ❖ Several systems proposed
 - Bunge-Wand-Weber
 - Dolce
- ❖ Advanced knowledge representation systems

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Bunge-Wand-Weber system

- ❖ Thing - independent existence
- ❖ Property/attribute - how we see things
- ❖ State - values of attributes of a thing
- ❖ Event - change of state
- ❖ History - sequence of events
- ❖ Coupling/interaction - dependent histories
- ❖ System - mutually coupled things
 - Composition - what is in
 - Environment - what is coupled but out
 - Structure - internal and external couplings
- ❖ Subsystem

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In the Bookseller Exchange

- ❖ Books, customers, booksellers are things
- ❖ The exchange is a thing
- ❖ Name, price, quantity are all properties
- ❖ Value of name, ISBN, price is state of a book
- ❖ Quantity in stock is state of a book inventory.
- ❖ A purchase is an event. Changes state of book inventory, customer account.
- ❖ Record of purchases by customers and inventory replenishments is history of a book inventory
- ❖ A book inventory and a customer account are coupled if that customer ever bought that book.
- ❖ Exchange audit trail couples all customers and booksellers to the exchange.

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In the Bookseller Exchange

- ❖ Customers and booksellers are coupled by transitive closure. Not necessarily all to all, though.
- ❖ Customers and booksellers are all coupled to the exchange.
- ❖ Purchases and customers are coupled. Books, booksellers and customers are coupled.
- ❖ Publishers are coupled to booksellers.
- ❖ Customers, booksellers, the exchange compose a system. Publishers are in its environment. All the couplings give the structure of the system.
- ❖ Transitive closure of customers and booksellers form subsystems

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Bunge-Wand-Weber system

- ❖ Input and output - causal relationships
- ❖ Types/subtypes
- ❖ Properties
 - Hereditary - property of component
 - Emergent - property of system only
 - Intrinsic - property of one thing
 - Mutual - property of coupling
 - In general - type level
 - In particular - object level
 - Part of

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In the Bookseller Exchange

- ❖ Purchase history causes inventory change history
- ❖ Purchase is input, inventory change output
- ❖ Books in print is a type, books handled by particular bookseller a subtype
- ❖ Year of sale is hereditary property of customer/bookseller system restricted to given year.
- ❖ Number of books sold is emergent
- ❖ Name is intrinsic property of customer
- ❖ Amount owing is mutual
- ❖ Rigid (essential) property is "in general"
- ❖ Name of particular customer is "in particular"

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Dolce system

- ❖ Entity
 - Abstract
 - Fact - logical proposition
 - Customer-bookseller systems are connected graphs
 - Set - mathematical set
 - {1,2,3,4}
 - Region
 - Temporal
 - o Today
 - Spatial
 - o This room

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Dolce system

- Endurant - exists in time
 - Object
 - o My status as a lecturer
 - o Your academic record
 - Aggregate (not an essential whole)
 - o Students present at this lecture
 - Feature (dependent essential whole)
 - o ISP service has peak times
 - Quality - value of a property an object has
 - o Use of this room now is for presenting a lecture
 - o ISP service at peak times is slow
 - Temporal - this lecture is today
 - Spatial - this lecture is in this room

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Dolce system

- Perdurant/occurrence - has temporal parts
 - Event - essential whole
 - Achievement - atomic: passing this course
 - Accomplishment - not atomic
 - o Completing requirements for a degree
 - Stative - not essential whole
 - State - all temporal parts same type as stative itself
 - o Studying for a degree
 - Process - temporal parts of different type
 - o Working on this course

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Perdurants and Endurants

- ❖ Endurants are created, changed and destroyed by perdurants
- ❖ A perdurant involves endurants
- ❖ Speech acts are perdurants (events).
- ❖ Institutional facts are endurants
- ❖ Statives are started, stopped and changed by events
- ❖ Being open for business is a state
- ❖ Carrying on business is a process

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Distinctions not Absolute

- ❖ In today's newspaper, last night's football game is a report of an event. Who played and who won is an achievement, the play-by-play is an accomplishment.
- ❖ To the spectators last night, the football game was a process
- ❖ To the neighbors, the parking restrictions in force during the game were a state. Also to the electricity supplier - the lights were on.
- ❖ Football as a sport is an endurant
 - Record of last night's game is an individual

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Systems compatible

- ❖ BWW thing is equivalent to Dolce entity
- ❖ Events are the same in both
- ❖ BWW property/attribute is Dolce quality/property
- ❖ Type/subtype are the same
- ❖ Part of same in both
- ❖ BWW state of a thing is the collection of Dolce qualities of the entity

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BWW Refines Dolce

- ❖ System is a kind of whole with parts
- ❖ History of a thing is a kind of stative
- ❖ Properties of a system are kinds of properties
 - Subclasses hereditary/emergent, intrinsic/mutual
- ❖ Properties in general are essential properties

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Dolce Refines BWW

- ❖ Abstract kind of thing
- ❖ Dolce stative represented in BWW as state of underlying endurant/thing
 - Stative open for business represented by "open" sign on unlocked door during business hours.
 - Stative threatening dog represented by growling property of dog
- ❖ Aggregate kind of thing
- ❖ Feature (emergent) property of a system

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Formal Ontologies

- ❖ Formal ontologies can be embedded in modeling tools
- ❖ Entity relationship modeling has some structures
- ❖ UML has more, including stative and event
- ❖ OMG Ontology Development Metamodel being designed to facilitate development of ontologies
- ❖ But the BWW and Dolce systems are richer still
- ❖ We will see how they can help

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Gateway for Educational Materials (GEM)

- ❖ Title
- ❖ GEMSubject
- ❖ Other Subject
- ❖ Keywords
- ❖ Description
- ❖ Coverage
- ❖ Creator
- ❖ Quality Indicators
- ❖ Standards
- ❖ Resource Type
- ❖ Grade Levels
- ❖ Essential Resources
- ❖ Duration
- ❖ Audience
- ❖ Pedagogy
- ❖ Date
- ❖ Identifier
- ❖ Rights Management
- ❖ Relation
- ❖ Format
- ❖ Cataloging Agency
- ❖ Online Provider
- ❖ Publisher
- ❖ Language

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Applying formal ontologies

- ❖ GEM is a list of properties, but no object
 - Implicit object, resource
 - Resource type defines subtypes of resource
- ❖ Formal structure helps makes implicit content explicit

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GEM Resource types

- ❖ Course - sequence of instructional units
- ❖ Unit of instruction - sequence of lesson plans
- ❖ Lesson plan -
- ❖ Activity - often part of lesson plan
- ❖ Educator's guide - supplement to lesson plan
- ❖ Implicit part/whole structure

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GEM Relation types

- ❖ hasBibliographicInfoIn - dependency relationship
- ❖ isRevisionHistoryFor - History of a thing
- ❖ isCriticalReviewOf - causal relation
 - Resource causes review
- ❖ isContentRatingFor - property or attribute

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Missing elements

- ❖ Nearly all GEM objects are endurants
- ❖ Endurants participate in perdurants
 - Creation, destruction events at least
 - Message events for updates
- ❖ Need query events
 - Perhaps Z39.50
- ❖ Need unifying and identifying relations and rigid properties for types

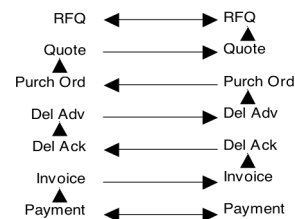
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Message Systems

- ❖ We have EDI-type message systems



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Message Systems

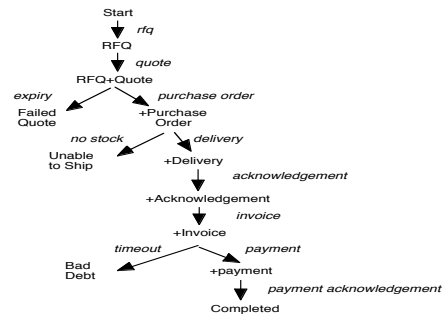
- ❖ Messages are events
- ❖ Records of the messages are endurants
- ❖ But the context for validity of a message depends on previous messages
- ❖ Suggests a stative (Dolce state, state in state-transition model).
- ❖ Statives are entities, so can have subclass structure.
- ❖ So BWW/Dolce suggest a state representation

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Message Systems



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Commentary

- ❖ Failed quote, Unable to ship, Bad debt, Completed are all essential wholes.
 - Rigid property is last message received declared final.
 - Independent classes
- ❖ Others not essential wholes
 - Rigid property is existence of indicated message
 - Subclass structure reverses arrows
 - RFQ most general class
 - +Payment most specific

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Benefits of Formal ontology

- ❖ Can suggest missing types of objects or structural relationships, resulting in a richer ontology
- ❖ Modeling tool can supply abstract data types for creating and manipulating structures.
 - Associations between perdurants and endurants
 - Histories of endurants
 - Metadata support
 - Mereological structures

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Application to Examples

- ❖ Z39.50 has endurants and perdurants, but does not have provision for histories
- ❖ Tic-Tac-Toe also has endurants and perdurants but no provision for history. Subclasses of *State* can be interpreted as statives.
- ❖ Others all endurants, so need to be embedded in systems with perdurants to do anything. All are examples of systems with subsystems.

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Summary: Key Terms

- ❖ **BWW and Dolce are formal upper ontologies.** Include systems, endurants, perdurants, subclasses, etc. Formal upper ontologies provide a rich meta vocabulary to help develop ontologies and suggest **abstract data types** which can be supported by ontology servers to make it easier to build rich ontologies.



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Resources

❖ Essential

- Notes chapter 7 Formal Upper Ontologies

❖ Further

- Weber, R, (1997) *Ontological Foundations of Information Systems* Coopers and Lybrand, especially chapter 2 (on-line on library site)
- Gangemi et al. (2002) Sweetening Ontologies with DOLCE European Knowledge Acquisition Workshop (on web site)
- Dewey, John Chapter 2 *Existence* from *Experience and Nature*. Relevant to the distinction between endurant and perdurant, and why the distinction is not absolute. (on-line on library site)